California
Manual on Uniform
Traffic Control Devices
for Streets and Highways
**(FHWA's MUTCD 2003 Edition,
as amended for use in California)**

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PART 4
HIGHWAY TRAFFIC SIGNALS

DRAFT
FOR COMMENT

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STATE OF CALIFORNIA
BUSINESS, TRANSPORTATION AND HOUSING AGENCY
DEPARTMENT OF TRANSPORTATION

PART 4. HIGHWAY TRAFFIC SIGNALS

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CHAPTER 4A. GENERAL

Section 4A.01 Types

Support:

The following types and uses of highway traffic signals are discussed in Part 4: traffic control signals; pedestrian signals; emergency-vehicle traffic control signals; traffic control signals for one-lane, two-way facilities; traffic control signals for freeway entrance ramps; traffic control signals for movable bridges; lane-use control signals; flashing beacons; and in-roadway lights.

Section 4A.02 Definitions Relating to Highway Traffic Signals

Standard:

The following technical terms, when used in Part 4, shall be defined as follows:

1. **Accessible Pedestrian Signal—a device that communicates information about pedestrian timing in nonvisual format such as audible tones, verbal messages, and/or vibrating surfaces.**
2. **Active Grade Crossing Warning System—the flashing-light signals, with or without warning gates, together with the necessary control equipment used to inform road users of the approach or presence of trains at highway-rail grade crossings or highway-light rail transit grade crossings.**
3. **Actuated Operation—a type of traffic control signal operation in which some or all signal phases are operated on the basis of actuation.**
4. **Actuation—initiation of a change in or extension of a traffic signal phase through the operation of any type of detector.**
5. **Approach—all lanes of traffic moving towards an intersection or a midblock location from one direction, including any adjacent parking lane(s).**
6. **Average Day—a day representing traffic volumes normally and repeatedly found at a location, typically a weekday when volumes are influenced by employment or a weekend day when volumes are influenced by entertainment or recreation.**
7. **Backplate—see Signal Backplate.**
8. **Beacon—a highway traffic signal with one or more signal sections that operates in a flashing mode.**
9. **Conflict Monitor—a device used to detect and respond to improper or conflicting signal indications and improper operating voltages in a traffic controller assembly.**
10. **Controller Assembly—a complete electrical device mounted in a cabinet for controlling the operation of a highway traffic signal.**
11. **Controller Unit—that part of a controller assembly that is devoted to the selection and timing of the display of signal indications.**
12. **Crosswalk—(a) that part of a roadway at an intersection included within the connections of the lateral lines of the sidewalks on opposite sides of the highway measured from the curbs or in the absence of curbs, from the edges of the traversable roadway, and in the absence of a sidewalk on one side of the roadway, the part of a roadway included within the extension of the lateral lines of the sidewalk at right angles to the centerline; (b) any portion of a roadway at an intersection or elsewhere distinctly indicated as a pedestrian crossing by lines on the surface, which may be supplemented by a contrasting pavement texture, style, or color.**
13. **Cycle Length—the time required for one complete sequence of signal indications.**
14. **Dark Mode—the lack of all signal indications at a signalized location. (The dark mode is most commonly associated with power failures, ramp meters, beacons, and some movable bridge signals.)**
15. **Detector—a device used for determining the presence or passage of vehicles or pedestrians.**
16. **Dual-Arrow Signal Section—a type of signal section designed to include both a yellow arrow and a green arrow.**
17. **Emergency Vehicle Traffic Control Signal—a special traffic control signal that assigns the right of-way to an authorized emergency vehicle.**

18. Flasher—a device used to turn highway traffic signal indications on and off at a repetitive rate of approximately once per second.
19. Flashing—an operation in which a highway traffic signal indication is turned on and off repetitively.
20. Flashing Mode—a mode of operation in which at least one traffic signal indication in each vehicular signal face of a highway traffic signal is turned on and off repetitively.
21. Full-Actuated Operation—a type of traffic control signal operation in which all signal phases function on the basis of actuation.
22. Highway Traffic Signal—a power-operated traffic control device by which traffic is warned or directed to take some specific action. These devices do not include signals at toll plazas, power-operated signs, illuminated pavement markers, warning lights (see Section 6F.78), or steady-burning electric lamps.
23. In-Roadway Lights—a special type of highway traffic signal installed in the roadway surface to warn road users that they are approaching a condition on or adjacent to the roadway that might not be readily apparent and might require the road users to slow down and/or come to a stop.
24. Intersection—(a) the area embraced within the prolongation or connection of the lateral curb lines, or if none, the lateral boundary lines of the roadways of two highways that join one another at, or approximately at, right angles, or the area within which vehicles traveling on different highways that join at any other angle might come into conflict; (b) the junction of an alley or driveway with a roadway or highway shall not constitute an intersection.
25. Intersection Control Beacon—a beacon used only at an intersection to control two or more directions of travel.
26. Interval—the part of a signal cycle during which signal indications do not change.
27. Interval Sequence—the order of appearance of signal indications during successive intervals of a signal cycle.
28. Lane-Use Control Signal—a signal face displaying signal indications to permit or prohibit the use of specific lanes of a roadway or to indicate the impending prohibition of such use.
29. Lens—see Signal Lens.
30. Louver—see Signal Louver.
31. Major Street—the street normally carrying the higher volume of vehicular traffic.
32. Malfunction Management Unit—same as Conflict Monitor.
33. Minor Street—the street normally carrying the lower volume of vehicular traffic.
34. Movable Bridge Resistance Gate—a type of traffic gate, which is located downstream of the movable bridge warning gate, that provides a physical deterrent to vehicle and/or pedestrian traffic when placed in the appropriate position.
35. Movable Bridge Signal—a highway traffic signal installed at a movable bridge to notify traffic to stop during periods when the roadway is closed to allow the bridge to open.
36. Movable Bridge Warning Gate—a type of traffic gate designed to warn, but not primarily to block, vehicle and/or pedestrian traffic when placed in the appropriate position.
37. Pedestrian Change Interval—an interval during which the flashing UPRAISED HAND (symbolizing DONT WALK) signal indication is displayed. When a verbal message is provided at an accessible pedestrian signal, the verbal message is "wait."
38. Pedestrian Clearance Time—the time provided for a pedestrian crossing in a crosswalk, after leaving the curb or shoulder, to travel to the far side of the traveled way or to a median.
39. Pedestrian Signal Head—a signal head, which contains the symbols WALKING PERSON (symbolizing WALK) and UPRAISED HAND (symbolizing DONT WALK), that is installed to direct pedestrian traffic at a traffic control signal.
40. Permissive Mode—a mode of traffic control signal operation in which, when a CIRCULAR GREEN signal indication is displayed, left or right turns are permitted to be made after yielding to pedestrians and/or oncoming traffic.

41. Platoon—a group of vehicles or pedestrians traveling together as a group, either voluntarily or involuntarily, because of traffic signal controls, geometrics, or other factors.
42. Preemption Control—the transfer of normal operation of a traffic control signal to a special control mode of operation.
43. Pretimed Operation—a type of traffic control signal operation in which none of the signal phases function on the basis of actuation.
44. Priority Control—a means by which the assignment of right-of-way is obtained or modified.
45. Protected Mode—a mode of traffic control signal operation in which left or right turns are permitted to be made when a left or right GREEN ARROW signal indication is displayed.
46. Pushbutton—a button to activate pedestrian timing.
47. Pushbutton Locator Tone—a repeating sound that informs approaching pedestrians that they are required to push a button to actuate pedestrian timing and that enables pedestrians who have visual disabilities to locate the pushbutton.
48. Ramp Control Signal—a highway traffic signal installed to control the flow of traffic onto a freeway at an entrance ramp or at a freeway-to-freeway ramp connection.
49. Ramp Meter—see Ramp Control Signal.
50. Red Clearance Interval—an optional interval that follows a yellow change interval and precedes the next conflicting green interval.
51. Right-of-Way (Assignment)—the permitting of vehicles and/or pedestrians to proceed in a lawful manner in preference to other vehicles or pedestrians by the display of signal indications.
52. Roadway Network—a geographical arrangement of intersecting roadways.
53. Semiactuated Operation—a type of traffic control signal operation in which at least one, but not all, signal phases function on the basis of actuation.
54. Separate Left-Turn Signal Face—a signal face for controlling a left-turn movement that sometimes displays a different color of circular signal indication than the adjacent through signal faces display.
55. Shared Left-Turn Signal Face—a signal face, for controlling both a left turn movement and the adjacent through movement, that always displays the same color of circular signal indication that the adjacent through signal face or faces display.
56. Signal Backplate—a thin strip of material that extends outward from and parallel to a signal face on all sides of a signal housing to provide a background for improved visibility of the signal indications.
57. Signal Coordination—the establishment of timed relationships between adjacent traffic control signals.
58. Signal Face—that part of a traffic control signal provided for controlling one or more traffic movements on a single approach.
59. Signal Head—an assembly of one or more signal sections.
60. Signal Housing—that part of a signal section that protects the light source and other required components.
61. Signal Indication—the illumination of a signal lens or equivalent device.
62. Signal Lens—that part of the signal section that redirects the light coming directly from the light source and its reflector, if any.
63. Signal Louver—a device that can be mounted inside a signal visor to restrict visibility of a signal indication from the side or to limit the visibility of the signal indication to a certain lane or lanes, or to a certain distance from the stop line.
64. Signal Phase—the right-of-way, yellow change, and red clearance intervals in a cycle that are assigned to an independent traffic movement or combination of movements.
65. Signal Section—the assembly of a signal housing, signal lens, and light source with necessary components to be used for providing one signal indication.
66. Signal System—two or more traffic control signals operating in signal coordination.
67. Signal Timing—the amount of time allocated for the display of a signal indication.

68. Signal Visor—that part of a signal section that directs the signal indication specifically to approaching traffic and reduces the effect of direct external light entering the signal lens.
69. Signal Warrant—a threshold condition that, if found to be satisfied as part of an engineering study, shall result in analysis of other traffic conditions or factors to determine whether a traffic control signal or other improvement is justified.
70. Speed Limit Sign Beacon—a beacon used to supplement a SPEED LIMIT sign.
71. Steady (Steady Mode)—the continuous illumination of a signal indication for the duration of an interval, signal phase, or consecutive signal phases.
72. Stop Beacon—a beacon used to supplement a STOP sign, a DO NOT ENTER sign, or a WRONG WAY sign.
73. Traffic Control Signal (Traffic Signal)—any highway traffic signal by which traffic is alternately directed to stop and permitted to proceed.
74. Vibrotactile Pedestrian Device—a device that communicates, by touch, information about pedestrian timing using a vibrating surface.
75. Visibility-Limited Signal Face or Signal Section—a type of signal face or signal section designed (or shielded, hooded, or louvered) to restrict the visibility of a signal indication from the side, to a certain lane or lanes, or to a certain distance from the stop line.
76. Walk Interval—an interval during which the WALKING PERSON (symbolizing WALK) signal indication is displayed. When a verbal message is provided at an accessible pedestrian signal, the verbal message is "walk sign."
77. Warning Beacon—a beacon used only to supplement an appropriate warning or regulatory sign or marker.
78. Yellow Change Interval—the first interval following the green interval during which the yellow signal indication is displayed.

CHAPTER 4B. TRAFFIC CONTROL SIGNALS—GENERAL

Section 4B.01 General

Standard:

A traffic control signal (traffic signal) shall be defined as any highway traffic signal by which traffic is alternately directed to stop and permitted to proceed.

Traffic shall be defined as pedestrians, bicyclists, ridden or herded animals, vehicles, streetcars, and other conveyances either singularly or together while using any highway for purposes of travel.

Support:

Words such as pedestrians and bicyclists are used redundantly in selected sections of Part 4 to encourage sensitivity to these elements of "traffic."

Standards for traffic control signals are important because traffic control signals need to attract the attention of a variety of road users, including those who are older, those with impaired vision, as well as those who are fatigued or distracted, or who are not expecting to encounter a signal at a particular location.

Section 4B.02 Basis of Installation or Removal of Traffic Control Signals

Guidance:

The selection and use of traffic control signals should be based on an engineering study of roadway, traffic, and other conditions.

Support:

A careful analysis of traffic operations, pedestrian and bicyclist needs, and other factors at a large number of signalized and unsignalized locations, coupled with engineering judgment, has provided a series of signal warrants, described in Chapter 4C, that define the minimum conditions under which installing traffic control signals might be justified.

Guidance:

Engineering judgment should be applied in the review of operating traffic control signals to determine whether the type of installation and the timing program meet the current requirements of all forms of traffic.

If changes in traffic patterns eliminate the need for a traffic control signal, consideration should be given to removing it and replacing it with appropriate alternative traffic control devices, if any are needed.

Option:

If the engineering study indicates that the traffic control signal is no longer justified, removal may be accomplished using the following steps:

A. Determine the appropriate traffic control to be used after removal of the signal.
B. Remove any sight-distance restrictions as necessary.
C. Inform the public of the removal study, for example by installing an informational sign (or signs) with the legend TRAFFIC SIGNAL UNDER STUDY FOR REMOVAL at the signalized location in a position where it is visible to all road users.
D. Flash or cover the signal heads for a minimum of 90 days, and install the appropriate stop control or other traffic control devices.
E. Remove the signal if the engineering data collected during the removal study period confirms that the signal is no longer needed. Instead of total removal of the traffic control signal, the poles and cables may remain in place after removal of the signal heads for continued analysis.

Standard:

Once a traffic signal at an intersection or pedestrian crossing has been energized, it shall not be turned off unless arrangements have been made for temporary control by traffic officers, temporary stop signs or an approved portable signal.

Section 4B.03 Advantages and Disadvantages of Traffic Control Signals

Support:

When properly used, traffic control signals are valuable devices for the control of vehicular and pedestrian traffic. They assign the right-of-way to the various traffic movements and thereby profoundly influence traffic flow.

Traffic control signals that are properly designed, located, operated, and maintained will have one or more of the following advantages:

A. They provide for the orderly movement of traffic.
B. They increase the traffic-handling capacity of the intersection if:
   1. Proper physical layouts and control measures are used, and
   2. The signal operational parameters are reviewed and updated (if needed) on a regular basis (as engineering judgment determines that significant traffic flow and/or land use changes have occurred) to maximize the ability of the traffic control signal to satisfy current traffic demands.
C. They reduce the frequency and severity of certain types of crashes, especially right-angle collisions.
D. They are coordinated to provide for continuous or nearly continuous movement of traffic at a definite speed along a given route under favorable conditions.
E. They are used to interrupt heavy traffic at intervals to permit other traffic, vehicular or pedestrian, to cross.

Traffic control signals are often considered a panacea for all traffic problems at intersections. This belief has led to traffic control signals being installed at many locations where they are not needed, adversely affecting the safety and efficiency of vehicular, bicycle, and pedestrian traffic.

Traffic control signals, even when justified by traffic and roadway conditions, can be ill-designed, ineffectively placed, improperly operated, or poorly maintained. Improper or unjustified traffic control signals can result in one or more of the following disadvantages:

A. Excessive delay;
B. Excessive disobedience of the signal indications;
C. Increased use of less adequate routes as road users attempt to avoid the traffic control signals; and
D. Significant increases in the frequency of collisions (especially rear-end collisions).

Section 4B.04 <u>Alternatives to Traffic Control Signals</u>

Guidance:

Since vehicular delay and the frequency of some types of crashes are sometimes greater under traffic signal control than under STOP sign control, consideration should be given to providing alternatives to traffic control signals even if one or more of the signal warrants has been satisfied.

Option:

These alternatives may include, but are not limited to, the following:

A. Installing signs along the major street to warn road users approaching the intersection;
B. Relocating the stop line(s) and making other changes to improve the sight distance at the intersection;
C. Installing measures designed to reduce speeds on the approaches;
D. Installing a flashing beacon at the intersection to supplement STOP sign control;
E. Installing flashing beacons on warning signs in advance of a STOP sign controlled intersection on major-and/or minor-street approaches;
F. Adding one or more lanes on a minor-street approach to reduce the number of vehicles per lane on the approach;
G. Revising the geometrics at the intersection to channelize vehicular movements and reduce the time required for a vehicle to complete a movement, which could also assist pedestrians;
H. Installing roadway lighting if a disproportionate number of crashes occur at night;
I. Restricting one or more turning movements, perhaps on a time-of-day basis, if alternate routes are available;
J. If the warrant is satisfied, installing multiway STOP sign control;
K. Installing a roundabout intersection; and
L. Employing other alternatives, depending on conditions at the intersection.

Section 4B.05 <u>Adequate Roadway Capacity</u>

Support:

The delays inherent in the alternating assignment of right-of-way at intersections controlled by traffic control signals can frequently be reduced by widening the major roadway, the minor roadway, or both

roadways. Widening the minor roadway often benefits the operations on the major roadway, because it reduces the green time that must be assigned to minor-roadway traffic. In urban areas, the effect of widening can be achieved by eliminating parking on intersection approaches. It is desirable to have at least two lanes for moving traffic on each approach to a signalized location. Additional width on the departure side of the intersection, as well as on the approach side, will sometimes be needed to clear traffic through the intersection effectively.

Guidance:

Adequate roadway capacity should be provided at a signalized location. Before an intersection is widened, the additional green time pedestrians need to cross the widened roadways should be considered to determine if it will exceed the green time saved through improved vehicular flow.

Support:

When the vehicular volume on a two-lane State highway is large enough to warrant traffic signals, usually there will be considerable congestion after the signals are installed unless the State highway is widened to four lanes at the intersection. Sometimes, it is also necessary to widen the intersecting road.

Guidance:

Where possible, the highway approaches and local road approaches should be widened to two lanes for through traffic, for a minimum of 60 m (200 ft) for traffic approaching the intersection and for a minimum of 100 m (330 ft) for traffic leaving the intersection. Additional widening for tapered sections should be provided at the ends of the added lanes. It may be necessary to prohibit parking in these areas and/or to provide left turn lanes. See Section 4B.104(CA) for financing.

Section 4B.101(CA) Traffic Signal Development Procedures – Introduction

Support:

General requirements for the development of traffic signal, lighting and electrical systems projects are noted in the Department of Transportation's Project Development Procedures Manual. See Section 1A.11 for information regarding this publication. The cost of traffic signals on Federal Aid highway projects is eligible for federal participation under certain conditions.

Option:

The preparation of a Project Study Report may be required for major traffic signal lighting and/or electrical system projects for scoping and programming purposes.

Guidance:

The Department of Transportation's Project Development Procedures Manual and the appropriate Program Advisor should be consulted to determine specific reporting requirements.

Section 4B.102(CA) Project Report

Standard:

The Department of Transportation's District shall prepare a project report of the investigation of conditions at locations where a new traffic signal is to be installed, an existing traffic signal is to be modified or an existing traffic signal is to be removed. The Department of Transportation's District Directors are authorized to approve project reports in accordance with the current departmental policies contained in the Project Development Procedures Manual. Three copies of the District-approved project report shall be forwarded to the Department of Transportation's Chief, State and Local Project Development. A project report shall be prepared whether the work is performed by the State or by others.

Guidance:

General requirements for project reports are noted in the Department of Transportation's Project Development Procedures Manual. A project report for the installation, modification (except for upgrading projects involving specific equipment) or removal of a traffic signal should include the following specific information:

1. Traffic Counts.
   a) Both pedestrian and vehicular traffic counts should include the periods of the average day when the signals would appear to be needed most. The counts should be at least eight hours in duration, not necessarily consecutive, but including a.m. and p.m. peak hours.

b) Traffic counts for a new signal shall be shown on appropriate Traffic Signal Warrant Sheets and a Directional Traffic Count Sheet. See Figures 4C-101(CA), 4C-102(CA) and Table 4C-101(CA).
c) Where pedestrian volumes are significant, show the volume on each crosswalk for the same periods as the vehicle count.
d) When estimated traffic volumes are used in establishing traffic signal warrants, they should be prepared on Form TS-10D. See Table 4C-101(CA).

2. Collision Diagram.
A collision diagram for the intersection covering the recent accident experience history. The diagram should cover a 3-year interval.
3. Condition Diagram.
A condition diagram showing existing roadway conditions. Any railroad grade crossing within 60 m (200 ft) of the intersection should be shown.
4. Improvement Diagram.
A diagram showing existing and proposed signals, phasing, channelization and other proposed improvements. This may be combined with 1, 2 and/or 3 on a single plan.
5. Estimate.
An estimate of the cost of the project (including State furnished materials) and the proposed method of financing.
6. Other Specialized Data When Appropriate:
a. Classification of Vehicles. The classification is required when it is a significant factor in affecting intersection capacity.
b. Critical Speed (85th percentile) of Approaching Vehicles. This is the speed at a point unaffected by existing controls.
c. Time-Space Diagram. When the project involves a coordinated traffic signal system.

Section 4B.103(CA) Submittals
Support:
General requirements for the submittal of plans, specifications and estimates are noted in the Department of Transportation's Project Development Procedures Manual and the PS&E Guide. See Section 1A.11 for information regarding these publications.
Standard:
All electrical plans shall bear the following: "Note: This plan accurate for electrical work only."

Section 4B.104(CA) Financing
Guidance:
Unless previously budgeted, the financing of a project should be considered only after receipt of the PS&E Report and cooperative agreements.
Support:
Normally, the costs of a new traffic signal or the modification of a signal or signal system are to be shared with a local agency.
Option:
In situations where a new traffic signal or a modification to an existing traffic signal or traffic signal system is urgently needed to improve safety or traffic flow on the State highway and the local agencies are unable to finance their prorated share of the cost, the State may accept a lesser participation, or even no participation, by the local authorities.
Standard:
The definition of "urgently needed" shall be made by the Department of Transportation's District Director.
The cost of small projects such as modifications to existing traffic signals (detectors, signal heads, mast arms, etc.) where the prorated share of the local agency is $3,000 or less, shall be at 100% State expense.

Section 4B.105(CA) Design Cost

Standard:

The following criteria shall apply in determining the amount of participation in the design cost by the State and a local agency:

a Where the State prepares plans for the installation or modification of a traffic signal or a traffic signal system on a State highway, the design costs should be shared with the local agency. Where the local agency is to prepare the plans, the State may participate in the design costs. Participation should be the same as construction cost participation and be covered by a cooperative agreement.

Guidance:

b Estimated design costs should be determined on the basis of an agreed fixed percentage of the total project costs. The fixed percentage should be based on historical design costs for projects in the price range concerned.

Standard:

c Where the State is requested by a local agency to prepare plans and specifications for a traffic signal project that does not involve State participation in the construction costs, the design costs shall be borne entirely by the local agency or others. The State may, however, assume the design engineering costs and the construction engineering costs, where the local agency agrees to pay all of the construction costs for a warranted project and where all of the costs would normally be shared on a prorated basis.

Section 4B.106(CA) Construction Costs - Conventional Highways

Standard:

The following criteria shall apply in determining the amount of the construction costs by the State and local agency for a traffic signal, safety lighting, and channelization or widening project on conventional State highways.

Channelization and/or Widening Costs. On cooperatively financed projects, the channelization and/or widening costs shall be shared as follows:

- Channelization on and/or widening of the State highway shall be at 100% State expense.
- Channelization on and/or widening of the local street shall be at 100% local agency expense.
- Where the local agency's portion of the channelization or widening is a minor part of the channelization or widening being constructed by the State and the local agency's share of the work amounts to $3,000, or less, the State may assume the entire cost of the channelization or widening.

Channelization and/or widening required, as a part of the conditions of a permit by a private party shall be at 100% expense of the private party.

In Cases A, B, and D listed below, the costs of constructing the electrical facilities are to be shared by the State and local agencies. The costs shall be shared on a prorated basis in the same ratio as the number of legs in the intersection under each agency's jurisdiction bears to the total number of legs.

Case A. Installation or Modification of a Traffic Signal and/or Safety Lighting at an Existing Intersection. When a traffic signal and/or safety lighting is to be installed or modified at the intersection of a State highway and a local road, local agency participation in the installation or modification costs shall be sought.

Guidance:

Case B. Existing Driveways at Existing Signalized Intersections. A private driveway that constitutes a leg at an existing signalized intersection should be treated as follows:

1. If the driveway does not generate appreciable traffic, no control is required.
2. If the driveway serves an area that generates sufficient traffic to constitute a problem, it should be controlled. One example of control is the use of a red flashing beacon and/or a RIGHT TURN ONLY (R41(CA)) sign to control egress from the private driveway. Another would be to provide signal indications for the private driveway.

Standard:

3. Costs shall be as in Case D.

Case C. A New Road or Driveway at an Existing Signalized Intersection. Where a new road or driveway is to be constructed to enter an existing "T" intersection, the cost of necessary right-of-way, traffic signal and/or safety lighting shall be at 100% local agency or permittee expense. The cost shall include the signal faces and detectors for the new approach and signal faces and detectors for left turns into the new approach and channelization, if necessary.

Case D. Installation of a Traffic Signal and/or Safety Lighting at an existing intersection with a Driveway. Where a traffic signal and/or safety lighting is to be installed at an existing intersection serving an area which generates sufficient traffic to constitute a problem that includes a private driveway as the fourth approach, the cost of signal and lighting equipment for the driveway approach shall be included in the cost of the entire installation.

Where one or more legs of the intersection are under the jurisdiction of a local agency, the construction costs shall be shared with the local agency. The cost of the driveway leg shall be included with the local agency's share. It shall be the responsibility of the local agency to obtain the right-of-way, right-of-entry or easement necessary to install and maintain the signal equipment to be located on private property.

Case E. Reconstruction of a Conventional State Highway. When it is necessary to widen or reconstruct a State highway, the reconstruction and relocation of traffic control devices and safety lighting systems, shall be at 100% State expense. Local participation for purposes of expediting a project should be accepted. Additional traffic control devices installed in connection with reconstruction of a conventional highway are to be treated as in Case A.

Case F. Relocation of a Conventional State Highway. When an existing State highway is relocated, the State will install warranted traffic control devices and safety lighting at State expense. Local participation will not be required. If, however, a local authority wishes to participate in a project in order to expedite it, local participation should be accepted.

Case G. Installation of a Traffic Signal and/or Safety Lighting at a Private Driveway or Privately Owned Street. The cost of a new traffic signal and/or safety lighting installed at a private driveway or privately owned street (i.e., not under the jurisdiction of a city or county) shall be entirely at the expense of the property owner or developer.

The permittee shall grant the State access rights to the private property at any time for the purpose of maintaining or timing the signal and lighting.

Upon installation, all rights, title and interest in the traffic signal equipment shall be granted to the State by the permittee. In the event that the State finds it advisable for the signals to be removed, the State will remove and salvage the equipment.

Case H. Reconstruction of Existing Facilities. When affected by State highway construction, existing street lighting, police and fire alarm systems, and similar systems owned by a city, county or publicly owned service district shall be relocated at the sole expense of the owner, unless prior rights can be established.

Case I. School Traffic Signals and Flashing Beacons. Where traffic signals and/or flashing beacons are justified only by the School Area Traffic Signal Warrant on a State highway, the installation shall be at 100% State expense. When any other warrant is met also, the cost is shared in the usual manner.

Section 4B.107(CA) Construction Costs – Freeways

Standard:

The installation of electrical work and channelization at an intersection of a freeway ramp and a local road shall be at 100% State expense if such improvements are warranted at the time the freeway is to be opened to traffic, or if they are estimated to be warranted within five years after the date the freeway is opened to traffic.

Support:

It can be difficult to accurately predict the traffic pattern at interchanges at the time of the freeway design. Therefore, the need for signals at the ramp connections to local roads cannot always be anticipated.

Standard:

If within five years after the date of completion of the freeway, the interchange does not operate in the manner intended, and signal warrants are met, it shall be the policy to provide signals, lighting, channelization or roadway widening as necessary to facilitate the flow of traffic through the interchange. This work shall be done entirely at State expense in the same manner as it would have been done had it been planned in the original freeway project. This shall include widening of roadway approaches to proposed signalized ramp intersections in accordance with present design practice entirely at State expense.

After the five-year period, the cost of installation shall be financed in the same manner as for existing intersections.

Guidance:

Approval by local agencies should be obtained for changes to roads under their jurisdiction.

Option:

In lieu of treating each ramp intersection individually and sharing the costs on the basis of the number of legs under each jurisdiction, the concept of the overall facility as described in the Department of Transportation's Maintenance Manual may be used. See Section 1A.11 for information regarding this publication.

Standard:

Frontage roads or portions of frontage roads, which serve as connections between ramps to or from the freeway and existing public roads and which are retained under State jurisdiction, shall be considered as freeway ramps and electrical work at the intersections shall be financed as described above.

Any time the interchange is revised by adding or relocating ramps, it is considered a new interchange and the cost of signals at the ramp terminals and/or the connection to the local road shall be at 100% State expense.

Section 4B.108(CA) Roadway Improvements by Local Agencies

Standard:

Any new connection of a local street to a State highway, including any electrical work, widening and/or channelization required within the State highway right of way, shall be at 100% local agency expense.

At existing intersections any relocation or improvement of electrical facilities due to widening and/or channelization of the local street shall be at 100% local agency expense.

Section 4B.109(CA) Cooperative Agreements

Support:

When a local agency participates in the various project costs, a cooperative agreement is required.

Standard:

Each agreement shall include a statement of ownership, maintenance and operation.

Support:

Preapproved agreement forms and procedure details are available.

Section 4B.110(CA) Engineering Services for Local Agencies

Standard:

Contracts with local agencies for the State to provide traffic signal control system engineering services shall include a clause relating to "Legal Relationships and Responsibilities".

Support:

Preapproved wording is available.

Section 4B.111(CA) Salvaged Electrical Equipment

Support:

A construction project sometimes includes the removal of traffic signal, lighting or other electrical equipment that is not to be reused on the particular project.

Guidance:

The determination as to whether particular electrical equipment is salvable should be made at the Department of Transportation's District level. The determination as to whether or not to salvage existing equipment should be made on

the basis of the economic benefit to the State and on the conservation of energy and/or materials that would result from salvaging and/or reinstallation. Equipment should be salvaged if it falls within one of the following categories:

- It is an item for which there is a foreseeable use.
- It is part of an electrical installation owned jointly with another agency and the other agency has requested the salvaged equipment.
- It is usable in some other Department of Transportation's District.
- It can be immediately disposed of by other means.

Standard:

All electrical equipment removed and determined not to be salvable shall become the property of the contractor.

Equipment determined to be salvable shall be disposed of as follows:

- If the electrical installation is jointly owned by the State and one or more local agencies, each of the owners shall share in the salvage value. The local agencies shall be given first choice in obtaining the salvaged equipment. The agency obtaining the salvaged equipment shall reimburse the other agency in accordance with the proportionate ownership.
- Where the State or local agency is replacing existing electrical equipment without the other agency participating in the cost of the new equipment, the salvaged equipment shall belong to the party or parties who bore the cost of the new equipment unless otherwise specified in an agreement or encroachment permit.

The salvage value shall be determined at the Department of Transportation's District level during preparation of the preliminary report.

Guidance:

The salvage value should be such that if the equipment were taken into State storage it could be used economically for maintenance or as State-furnished material on contracts. The estimated salvage value should make the equipment more attractive to local agencies than the money representing the other partner's share of the salvage value. Wire and wiring supplies such as conduit, junction boxes, and connectors, and other materials should be considered as a lot at no value, or in any case, not more than the nominal sum of $1.

Support:

Often, salvaged electrical equipment is available for use on new installations; in many cases this will result in considerable savings.

Section 4B.112(CA) Encroachment Permits

Standard:

Encroachment permits are required for a local agency or a private party to install or modify traffic signals and street lighting on a State highway.

Guidance:

Plans and Specifications prepared by Permittees should conform to State Standard Specifications, Standard Plans and be submitted to the Department of Transportation's District for review and approval.

Standard:

In each case, a statement of ownership, maintenance and operation shall be included in the permit.

Support:

A Permit Engineering Evaluation Report (PEER) may be prepared in lieu of a project report for all projects estimated to cost $1,000,000 or less, as part of the encroachment permit review process. Instructions for PEER's are found in the Department of Transportation's Project Development Procedures Manual and the Encroachment Permits Manual. See Section 1A.11 for information regarding these publications.

Standard:

All projects financed, in whole or in part, from retail transactions and use taxes and projects costing more than $1,000,000 requires a cooperative agreement.

Section 4B.113(CA) Modifications of Existing Signals

Guidance:

Where existing signals are to be modified, construction plans should include a separate plan of the existing system as well as a plan showing the modifications.

Option:

It may also be necessary to include a tabulation on the plan showing such appurtenances as backplates and special signal faces that may be difficult to discern on a complicated plan.

Guidance:

The design of any signal modification project should include adequate consideration for keeping the existing signals in operation while the modification work is being done.

Section 4B.114(CA) Signals on Poles Owned by Others

Option:

Traffic signal equipment may be attached to poles owned by utility companies or other agencies when it is desired to keep the number of poles at an intersection to a minimum.

Guidance:

In such cases, the Agency should enter into an agreement with the owner of the pole. The agreement should be written to hold the owner of the pole free of liability relative to operation of the traffic signal or damage to the pole and to make the State or Local Transportation Agency responsible for moving the equipment in the event the pole is removed or relocated.

CHAPTER 4C. TRAFFIC CONTROL SIGNAL NEEDS STUDIES

Section 4C.01 Studies and Factors for Justifying Traffic Control Signals

Standard:

An engineering study of traffic conditions, pedestrian characteristics, and physical characteristics of the location shall be performed to determine whether installation of a traffic control signal is justified at a particular location.

The investigation of the need for a traffic control signal shall include an analysis of the applicable factors contained in the following traffic signal warrants and other factors related to existing operation and safety at the study location:

Warrant 1, Eight-Hour Vehicular Volume.

Warrant 2, Four-Hour Vehicular Volume.

Warrant 3, Peak Hour.

Warrant 4, Pedestrian Volume.

Warrant 5, School Crossing.

Warrant 6, Coordinated Signal System.

Warrant 7, Crash Experience.

Warrant 8, Roadway Network.

The satisfaction of a traffic signal warrant or warrants shall not in itself require the installation of a traffic control signal.

Support:

Sections 8D.07 and 10D.05 contain information regarding the use of traffic control signals instead of gates and/or flashing light signals at highway-railroad grade crossings and highway-light rail transit grade crossings, respectively.

Guidance:

A traffic control signal should not be installed unless one or more of the factors described in this Chapter are met.

A traffic control signal should not be installed unless an engineering study indicates that installing a traffic control signal will improve the overall safety and/or operation of the intersection.

A traffic control signal should not be installed if it will seriously disrupt progressive traffic flow.

The study should consider the effects of the right-turn vehicles from the minor-street approaches. Engineering judgment should be used to determine what, if any, portion of the right-turn traffic is subtracted from the minor-street traffic count when evaluating the count against the above signal warrants.

Engineering judgment should also be used in applying various traffic signal warrants to cases where approaches consist of one lane plus one left-turn or right-turn lane. The site-specific traffic characteristics dictate whether an approach should be considered as one lane or two lanes. For example, for an approach with one lane for through and right-turning traffic plus a left-turn lane, engineering judgment could indicate that it should be considered a one-lane approach if the traffic using the left-turn lane is minor. In such a case, the total traffic volume approaching the intersection should be applied against the signal warrants as a one-lane approach. The approach should be considered two lanes if approximately half of the traffic on the approach turns left and the left-turn lane is of sufficient length to accommodate all left-turn vehicles.

Similar engineering judgment and rationale should be applied to a street approach with one lane plus a right-turn lane. In this case, the degree of conflict of minor-street right-turn traffic with traffic on the major street should be considered. Thus, right-turn traffic should not be included in the minor-street volume if the movement enters the major street with minimal conflict. The approach should be evaluated as a one-lane approach with only the traffic volume in the through/left-turn lane considered.

At a location that is under development or construction and where it is not possible to obtain a traffic count that would represent future traffic conditions, hourly volumes should be estimated as part of an engineering study for comparison with traffic signal warrants. Except for locations where the engineering study uses the satisfaction of Warrant 8 to justify a signal, a traffic control signal installed under projected conditions should have an engineering study done within 1 year of putting the signal into stop-and-go

operation to determine if the signal is justified. If not justified, the signal should be taken out of stop-and-go operation or removed.

For signal warrant analysis, a location with a wide median, even if the median width is greater than 9 m (30 ft), should be considered as one intersection.

Option:

At an intersection with a high volume of left-turn traffic from the major street, the signal warrant analysis may be performed in a manner that considers the higher ~~of the major-street left-turn volumes as the "minor-street" volume and the corresponding single direction of opposing traffic on the major street as the "major-street" volume~~ volume of the major-street left-turn volumes plus the higher volume minor-street approach as the "minor street" volume and both approaches of the major street minus the higher of the major-street left-turn volume as "major street" volume.

For signal warrant analysis, bicyclists may be counted as either vehicles or pedestrians.

Support:

When performing a signal warrant analysis, bicyclists riding in the street with other vehicular traffic are usually counted as vehicles and bicyclists who are clearly using pedestrian facilities are usually counted as pedestrians.

Option:

Engineering study data may include the following:

A. The number of vehicles entering the intersection in each hour from each approach during 12 hours of an average day. It is desirable that the hours selected contain the greatest percentage of the 24-hour traffic volume.
B. Vehicular volumes for each traffic movement from each approach, classified by vehicle type (heavy trucks, passenger cars and light trucks, public-transit vehicles, and, in some locations, bicycles), during each 15-minute period of the 2 hours in the morning and 2 hours in the afternoon during which total traffic entering the intersection is greatest.
C. Pedestrian volume counts on each crosswalk during the same periods as the vehicular counts in Item B above and during hours of highest pedestrian volume. Where young, elderly, and/or persons with physical or visual disabilities need special consideration, the pedestrians and their crossing times may be classified by general observation.
D. Information about nearby facilities and activity centers that serve the young, elderly, and/or persons with disabilities, including requests from persons with disabilities for accessible crossing improvements at the location under study. These persons might not be adequately reflected in the pedestrian volume count if the absence of a signal restrains their mobility.
E. The posted or statutory speed limit or the 85th-percentile speed on the uncontrolled approaches to the location.
F. A condition diagram showing details of the physical layout, including such features as intersection geometrics, channelization, grades, sight-distance restrictions, transit stops and routes, parking conditions, pavement markings, roadway lighting, driveways, nearby railroad crossings, distance to nearest traffic control signals, utility poles and fixtures, and adjacent land use.
G. A collision diagram showing crash experience by type, location, direction of movement, severity, weather, time of day, date, and day of week for at least 1 year.

The following data, which are desirable for a more precise understanding of the operation of the intersection, may be obtained during the periods specified in Item B of the preceding paragraph:

A. Vehicle-hours of stopped time delay determined separately for each approach.
B. The number and distribution of acceptable gaps in vehicular traffic on the major street for entrance from the minor street.
C. The posted or statutory speed limit or the 85th-percentile speed on controlled approaches at a point near to the intersection but unaffected by the control.
D. Pedestrian delay time for at least two 30-minute peak pedestrian delay periods of an average weekday or like periods of a Saturday or Sunday.
E. Queue length on stop-controlled approaches.

Standard:

Delay, congestion, approach conditions, driver confusion, future land use or other evidence of the need for right of way assignment beyond that which could be provided by stop sign shall be demonstrated.

Support:

Figure 4C–101(CA) and Table 4C-101(CA) are examples of warrant sheets.

Guidance:

Table 4C-101(CA) should be used only for new intersections or other locations where it is not reasonable to count actual traffic volumes.

Section 4C.02 Warrant 1, Eight-Hour Vehicular Volume

Support:

The Minimum Vehicular Volume, Condition A, is intended for application at locations where a large volume of intersecting traffic is the principal reason to consider installing a traffic control signal.

The Interruption of Continuous Traffic, Condition B, is intended for application at locations where Condition A is not satisfied and where the traffic volume on a major street is so heavy that traffic on a minor intersecting street suffers excessive delay or conflict in entering or crossing the major street.

It is intended that Warrant 1 be treated as a single warrant. If Condition A is satisfied, then the criteria for Warrant 1 is satisfied and Condition B and the combination of Conditions A and B are not needed. Similarly, if Condition B is satisfied, then the criteria for Warrant 1 is satisfied and the combination of Conditions A and B is not needed.

Standard:

The need for a traffic control signal shall be considered if an engineering study finds that one of the following conditions exist for each of any 8 hours of an average day:

A. The vehicles per hour given in both of the 100 percent columns of Condition A in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection; or

B. The vehicles per hour given in both of the 100 percent columns of Condition B in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection.

In applying each condition the major-street and minor-street volumes shall be for the same 8 hours. On the minor street, the higher volume shall not be required to be on the same approach during each of these 8 hours.

Option:

If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds ~~70 km/h~~ 64 km/h or exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, the traffic volumes in the 70 percent columns in Table 4C-1 may be used in place of the 100 percent columns.

Guidance:

The combination of Conditions A and B is intended for application at locations where Condition A is not satisfied and Condition B is not satisfied and should be applied only after an adequate trial of other alternatives that could cause less delay and inconvenience to traffic has failed to solve the traffic problems.

Standard:

The need for a traffic control signal shall be considered if an engineering study finds that both of the following conditions exist for each of any 8 hours of an average day:

A. The vehicles per hour given in both of the 80 percent columns of Condition A in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection; and

B. The vehicles per hour given in both of the 80 percent columns of Condition B in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection.

Table 4C-1. Warrant 1, Eight-Hour Vehicular Volume

Condition A—Minimum Vehicular Volume									
Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1.....	1.....	500	400	350	280	150	120	105	84
2 or more...	1.....	600	480	420	336	150	120	105	84
2 or more...	2 or more...	600	480	420	336	200	160	140	112
1.....	2 or more....	500	400	350	280	200	160	140	112

Condition B—Interruption of Continuous Traffic									
Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1.....	1.....	750	600	525	420	75	60	53	42
2 or more...	1.....	900	720	630	504	75	60	53	42
2 or more...	2 or more...	900	720	630	504	100	80	70	56
1.....	2 or more....	750	600	525	420	100	80	70	56

[a] Basic minimum hourly volume.
[b] Used for combination of Conditions A and B after adequate trial of other remedial measures.
[c] May be used when the major-street speed exceeds 70 km/h or exceeds 40 mph or in an isolated community with a population of less than 10,000.
[d] May be used for combination of Conditions A and B after adequate trial of other remedial measures when the major-street speed exceeds 70 km/h or exceeds 40 mph or in an isolated community with a population of less than 10,000.

These major-street and minor-street volumes shall be for the same 8 hours for each condition; however, the 8 hours satisfied in Condition A shall not be required to be the same 8 hours satisfied in Condition B. On the minor street, the higher volume shall not be required to be on the same approach during each of the 8 hours.

Option:

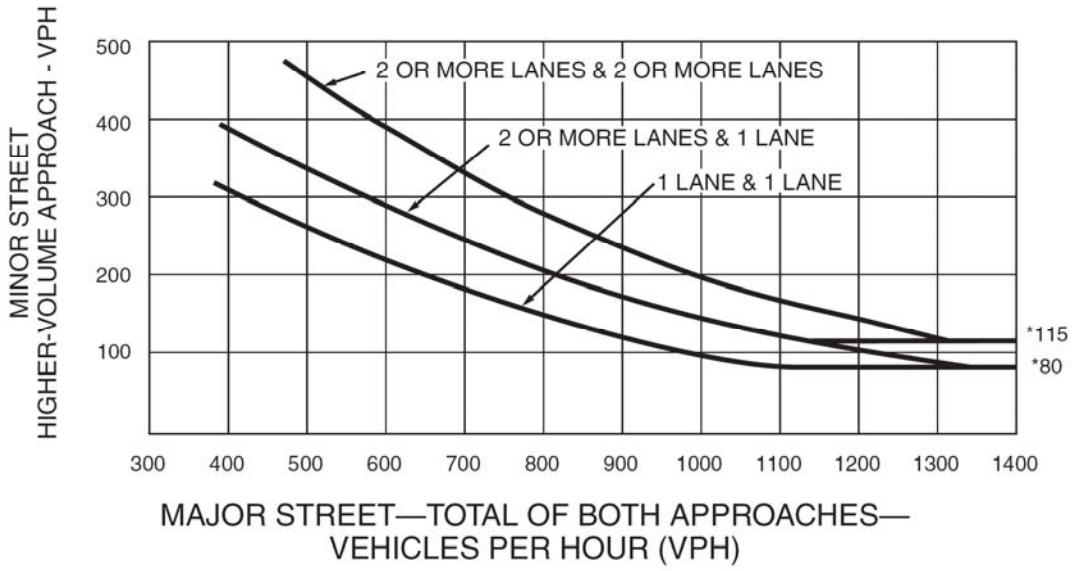
If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 70 km/h or exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, the traffic volumes in the 56 percent columns in Table 4C-1 may be used in place of the 80 percent columns.

Section 4C.03 Warrant 2, Four-Hour Vehicular Volume

Support:

The Four-Hour Vehicular Volume signal warrant conditions are intended to be applied where the volume of intersecting traffic is the principal reason to consider installing a traffic control signal.

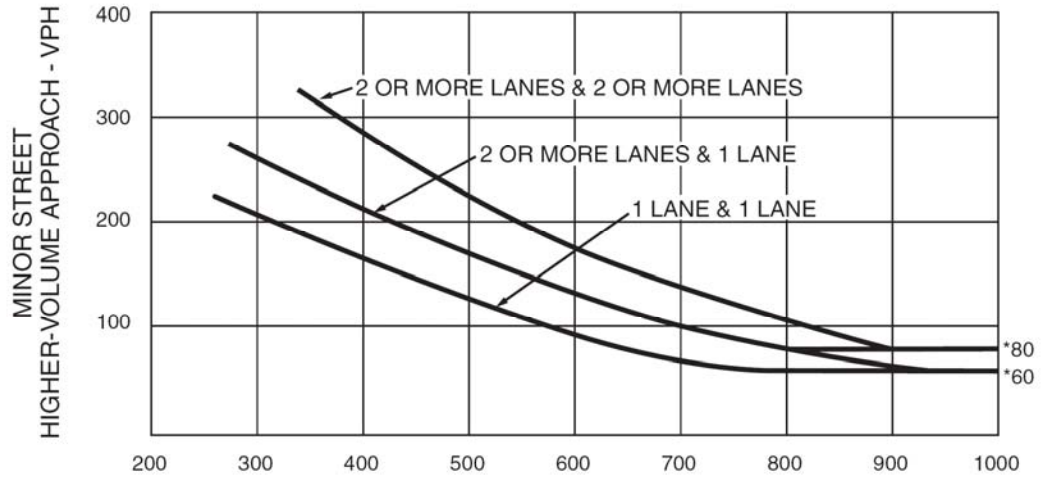
Figure 4C-1. Warrant 2, Four-Hour Vehicular Volume



*Note: 115 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 80 vph applies as the lower threshold volume for a minor-street approach with one lane.

Figure 4C-2. Warrant 2, Four-Hour Vehicular Volume (70% Factor)

(COMMUNITY LESS THAN 10,000 POPULATION OR ABOVE ~~70 km/~~64 km/h OR ABOVE 40 mph ON MAJOR STREET)



*Note: 80 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 60 vph applies as the lower threshold volume for a minor-street approach with one lane.

Standard:

The need for a traffic control signal shall be considered if an engineering study finds that, for each of any 4 hours of an average day, the plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher-volume minor-street approach (one direction only) all fall above the applicable curve in Figure 4C-1 for the existing combination of approach lanes. On the minor street, the higher volume shall not be required to be on the same approach during each of these 4 hours.

Option:

If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds ~~70 km/h~~ 64 km/h or exceeds 40 mph or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, Figure 4C-2 may be used in place of Figure 4C-1.

Section 4C.04 Warrant 3, Peak Hour

Support:

The Peak Hour signal warrant is intended for use at a location where traffic conditions are such that for a minimum of 1 hour of an average day, the minor-street traffic suffers undue delay when entering or crossing the major street.

Standard:

This signal warrant shall be applied only in unusual cases, such as office complexes, manufacturing plants, industrial complexes, or high-occupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time.

The need for a traffic control signal shall be considered if an engineering study finds that the criteria in either of the following two categories are met:

A. If all three of the following conditions exist for the same 1 hour (any four consecutive 15-minute periods) of an average day:

1. The total stopped time delay experienced by the traffic on one minor-street approach (one direction only) controlled by a STOP sign equals or exceeds: 4 vehicle-hours for a one-lane approach; or 5 vehicle-hours for a two-lane approach, and

2. The volume on the same minor-street approach (one direction only) equals or exceeds 100 vehicles per hour for one moving lane of traffic or 150 vehicles per hour for two moving lanes, and

3. The total entering volume serviced during the hour equals or exceeds 650 vehicles per hour for intersections with three approaches or 800 vehicles per hour for intersections with four or more approaches.

B. The plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher-volume minor-street approach (one direction only) for 1 hour (any four consecutive 15-minute periods) of an average day falls above the applicable curve in Figure 4C-3 for the existing combination of approach lanes.

Option:

If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds ~~70 km/h~~ 64 km/h or exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, Figure 4C-4 may be used in place of Figure 4C-3 to satisfy the criteria in the second category of the Standard.

Section 4C.05 Warrant 4, Pedestrian Volume

Support:

The Pedestrian Volume signal warrant is intended for application where the traffic volume on a major street is so heavy that pedestrians experience excessive delay in crossing the major street.

Standard:

The need for a traffic control signal at an intersection or midblock crossing shall be considered if an engineering study finds that both of the following criteria are met:

A. The pedestrian volume crossing the major street at an intersection or midblock location during an average day is 100 or more for each of any 4 hours or 190 or more during any 1 hour; and

B. There are fewer than 60 gaps per hour in the traffic stream of adequate length to allow pedestrians to cross during the same period when the pedestrian volume criterion is satisfied. Where there is a divided street having a median of sufficient width for pedestrians to wait, the requirement applies separately to each direction of vehicular traffic.

The Pedestrian Volume signal warrant shall not be applied at locations where the distance to the nearest traffic control signal along the major street is less than 90 m (300 ft), unless the proposed traffic control signal will not restrict the progressive movement of traffic.

If this warrant is met and a traffic control signal is justified by an engineering study, the traffic control signal shall be equipped with pedestrian signal heads conforming to requirements set forth in Chapter 4E.

Guidance:

If this warrant is met and a traffic control signal is justified by an engineering study, then:

A. If at an intersection, the traffic control signal should be traffic-actuated and should include pedestrian detectors.

B. If at a nonintersection crossing, the traffic control signal should be pedestrian-actuated, parking and other sight obstructions should be prohibited for at least 30 m (100 ft) in advance of and at least 6.1 m (20 ft) beyond the crosswalk, and the installation should include suitable standard signs and pavement markings.

C. Furthermore, if installed within a signal system, the traffic control signal should be coordinated.

Option:

The criterion for the pedestrian volume crossing the major roadway may be reduced as much as 50 percent if the average crossing speed of pedestrians is less than 1.2 m/sec (4 ft/sec).

A traffic control signal may not be needed at the study location if adjacent coordinated traffic control signals consistently provide gaps of adequate length for pedestrians to cross the street, even if the rate of gap occurrence is less than one per minute.

Section 4C.06 <u>Warrant 5, School Crossing</u>

Support:

The School Crossing signal warrant is intended for application where the fact that school children cross the major street is the principal reason to consider installing a traffic control signal.

Standard:

The need for a traffic control signal shall be considered when an engineering study of the frequency and adequacy of gaps in the vehicular traffic stream as related to the number and size of groups of school children at an established school crossing across the major street shows that the number of adequate gaps in the traffic stream during the period when the children are using the crossing is less than the number of minutes in the same period (see Section 7A.03) and there are a minimum of 20 students during the highest crossing hour.

Before a decision is made to install a traffic control signal, consideration shall be given to the implementation of other remedial measures, such as warning signs and flashers, school speed zones, school crossing guards, or a grade-separated crossing.

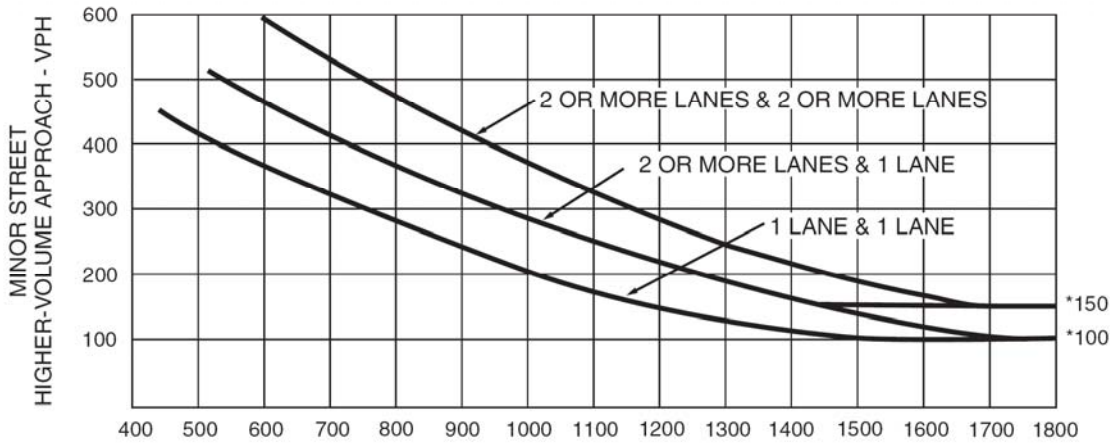
The School Crossing signal warrant shall not be applied at locations where the distance to the nearest traffic control signal along the major street is less than 90 m (300 ft), unless the proposed traffic control signal will not restrict the progressive movement of traffic.

Guidance:

If this warrant is met and a traffic control signal is justified by an engineering study, then:

A. If at an intersection, the traffic control signal should be traffic-actuated and should include pedestrian detectors.

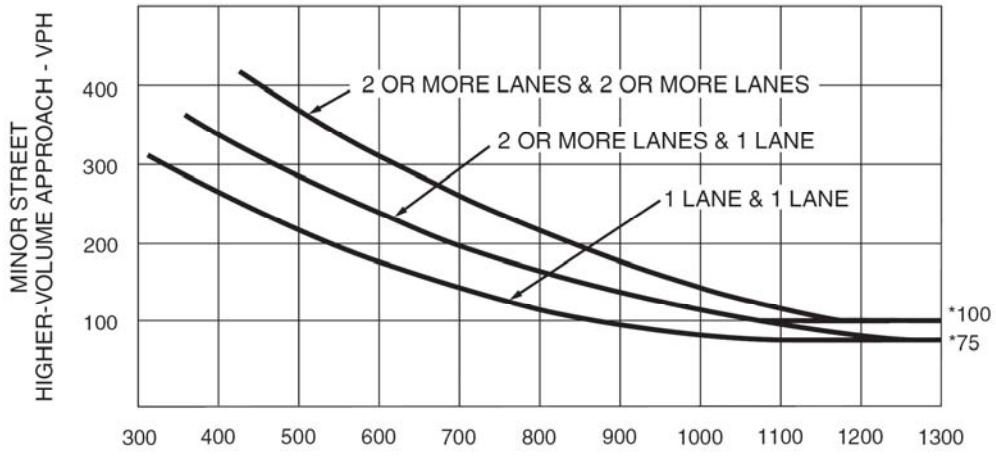
Figure 4C-3. Warrant 3, Peak Hour



*Note: 150 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 100 vph applies as the lower threshold volume for a minor-street approach with one lane.

Figure 4C-4. Warrant 3, Peak Hour (70% Factor)

(COMMUNITY LESS THAN 10,000 POPULATION OR ABOVE ~~70 km/h~~ 64 km/h OR ABOVE 40 mph ON MAJOR STREET)



*Note: 100 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 75 vph applies as the lower threshold volume for a minor-street approach with one lane.

B. If at a nonintersection crossing, the traffic control signal should be pedestrian-actuated, parking and other sight obstructions should be prohibited for at least 30 m (100 ft) in advance of and at least 6.1 m (20 ft) beyond the crosswalk, and the installation should include suitable standard signs and pavement markings.

C. Furthermore, if installed within a signal system, the traffic control signal should be coordinated.

Option:

Flashing beacons at school crosswalks may be installed on State highways in accordance with CVC Sections 21372 and 21373.

The following alternative criterion may be used for determining if a school crossing traffic signal is justified under this warrant:

1. When other warrants in this Chapter are met AND
2. No other controlled crossing is located within 180 m (600 ft) AND;
3. Urban Areas - 500 vehicles and 100 school pedestrians for each of any two hours (not necessarily consecutive) daily while students are crossing to or from school; or 500 vehicles for each of any two hours daily while students are crossing to or from school and a total of 500 school pedestrians during the entire day. OR
4. Rural Areas - 350 vehicles and 70 school pedestrians for each of any two hours (not necessarily consecutive) daily while students are crossing to or from school; or 350 vehicles for each of any two hours (not necessarily consecutive) daily while students are crossing to or from school and minimum total of 350 school pedestrians during the entire day.

Guidance:

When the critical (85th percentile) approach speed exceeds 55 km/h (35 mph) or the sight distance to the intersection is less than the required stopping sight distance, rural criteria should be applied.

Section 4C.07 Warrant 6, Coordinated Signal System

Support:

Progressive movement in a coordinated signal system sometimes necessitates installing traffic control signals at intersections where they would not otherwise be needed in order to maintain proper platooning of vehicles.

Standard:

The need for a traffic control signal shall be considered if an engineering study finds that one of the following criteria is met:

A. On a one-way street or a street that has traffic predominantly in one direction, the adjacent traffic control signals are so far apart that they do not provide the necessary degree of vehicular platooning.

B. On a two-way street, adjacent traffic control signals do not provide the necessary degree of platooning and the proposed and adjacent traffic control signals will collectively provide a progressive operation.

Guidance:

The Coordinated Signal System signal warrant should not be applied where the resultant spacing of traffic control signals would be less than 300 m (1,000 ft).

Section 4C.08 Warrant 7, Crash Experience

Support:

The Crash Experience signal warrant conditions are intended for application where the severity and frequency of crashes are the principal reasons to consider installing a traffic control signal.

Standard:

The need for a traffic control signal shall be considered if an engineering study finds that all of the following criteria are met:

A. Adequate trial of alternatives with satisfactory observance and enforcement has failed to reduce the crash frequency; and

B. Five or more reported crashes, of types susceptible to correction by a traffic control signal, have occurred within a 12-month period, each crash involving personal injury or property damage apparently exceeding the applicable requirements for a reportable crash; and

C. For each of any 8 hours of an average day, the vehicles per hour (vph) given in both of the 80 percent columns of Condition A in Table 4C-1 (see Section 4C.02), or the vph in both of the 80 percent columns of Condition B in Table 4C-1 exists on the major-street and the higher-volume minor-street approach, respectively, to the intersection, or the volume of pedestrian traffic is not less than 80 percent of the requirements specified in the Pedestrian Volume warrant. These major-street and minor-street volumes shall be for the same 8 hours. On the minor street, the higher volume shall not be required to be on the same approach during each of the 8 hours.

Option:

If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 70 km/h or exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, the traffic volumes in the 56 percent columns in Table 4C-1 may be used in place of the 80 percent columns.

Section 4C.09 Warrant 8, Roadway Network

Support:

Installing a traffic control signal at some intersections might be justified to encourage concentration and organization of traffic flow on a roadway network.

Standard:

The need for a traffic control signal shall be considered if an engineering study finds that the common intersection of two or more major routes meets one or both of the following criteria:

A. The intersection has a total existing, or immediately projected, entering volume of at least 1,000 vehicles per hour during the peak hour of a typical weekday and has 5-year projected traffic volumes, based on an engineering study, that meet one or more of Warrants 1, 2, and 3 during an average weekday; or

B. The intersection has a total existing or immediately projected entering volume of at least 1,000 vehicles per hour for each of any 5 hours of a nonnormal business day (Saturday or Sunday).

A major route as used in this signal warrant shall have one or more of the following characteristics:

A. It is part of the street or highway system that serves as the principal roadway network for through traffic flow; or

B. It includes rural or suburban highways outside, entering, or traversing a City; or

C. It appears as a major route on an official plan, such as a major street plan in an urban area traffic and transportation study.

Section 4C.101(CA) Function of School Crossing Traffic Signals

Support:

A traffic signal assigns intersection right-of-way and promotes the orderly movement of pedestrians and vehicles. However, improper signal controls sometimes lead to intentional violations, unnecessary delays and traffic diversion to less desirable routes.

Section 4C.102(CA) Criterion for School Crossing Traffic Signals

Standard:

1. The signal shall be designed for full-time operation.
2. Pedestrian signal faces of the International Symbol type shall be installed at all marked crosswalks at signalized intersections along the "Suggested Route to School."
3. If an intersection is signalized under this guideline for school pedestrians, the entire intersection shall be signalized.

4. School area traffic signals shall be traffic actuated type with push buttons or other detectors for pedestrians.

Option:

Non-intersection school pedestrian crosswalk locations may be signalized when justified.

Section 4C.103(CA) Bicycle Signal Warrant

Guidance:

A bicycle signal should be considered for use only when the volume and collision or volume and geometric warrants have been met:

1. Volume; When W = B x V and W $\geq$ 50,000 and B $\geq$ 50.
   Where: W is the volume warrant. B is the number of bicycles at the peak hour entering the intersection. V is the number of vehicles at the peak hour entering the intersection. B and V shall use the same peak hour.
2. Collision; When 2 or more bicycle/vehicle collisions of types susceptible to correction by a bicycle signal have occurred over a 12-month period and the responsible public works official determines that a bicycle signal will reduce the number of collisions.
3. Geometric; (a) Where a separate bicycle/ multi use path intersects a roadway. (b) At other locations to facilitate a bicycle movement that is not permitted for a motor vehicle.

Figure 4C-101 (CA). Traffic Signal Warrants Worksheet (Sheet 1 of 4)

DIST _____ CO _____ RTE _____ KPM _____

CALC _____ DATE _____
CHK _____ DATE _____

Major St: _____ Critical Approach Speed _____ km/h
Minor St: _____ Critical Approach Speed _____ km/h

Critical speed of major street traffic > 64 km/h (40 mph)..... ☐
or
In built up area of isolated community of < 10,000 population..... ☐
} **RURAL (R)**

☐ **URBAN (U)**

WARRANT 1 - Eight Hour Vehicular Volume

Condition A - Minimum Vehicle Volume

100% SATISFIED YES ☐ NO ☐
80% SATISFIED YES ☐ NO ☐

APPROACH LANES	MINIMUM REQUIREMENTS (80% SHOWN IN BRACKETS) 1 U	1 R	2 or More U	2 or More R	Hour							
Both Approaches Major Street	500 (400)	350 (280)	600 (480)	420 (336)								
Highest Approaches Minor Street	150 (120)	105 (84)	200 (160)	140 (112)								

Condition B - Interruption of Continuous Traffic

100% SATISFIED YES ☐ NO ☐
80% SATISFIED YES ☐ NO ☐

APPROACH LANES	MINIMUM REQUIREMENTS (80% SHOWN IN BRACKETS) 1 U	1 R	2 or More U	2 or More R	Hour							
Both Approaches Major Street	750 (600)	525 (420)	900 (720)	630 (504)								
Highest Approaches Minor Street	75 (60)	53 (42)	100 (80)	70 (56)								

Combination of Conditions A & B

SATISFIED YES ☐ NO ☐

REQUIREMENT	WARRANT	✓	FULFILLED
TWO WARRANTS SATISFIED 80%	1. MINIMUM VEHICULAR VOLUME		Yes ☐ No ☐
	2. INTERRUPTION OF CONTINUOUS TRAFFIC		

Figure 4C-101 (CA). Traffic Signal Warrants Worksheet (Sheet 2 of 4)

WARRANT 2 - Four Hour Vehicular Volume **SATISFIED* YES ☐ NO ☐**

Record hourly vehicular volumes for four hours.

APPROACH LANES	One	2 or More				Hour
Both Approaches - Major Street						
Highest Approaches - Minor Street						

*All plotted points fall above the curves in MUTCD Figure 4C-1 or 4C-2. Yes ☐ No ☐

WARRANT 3 - Peak Hour **PART A or PART B SATISFIED YES ☐ NO ☐**

PART A **SATISFIED YES ☐ NO ☐**

(All parts 1, 2, and 3 below must be satisfied)

1. The total delay experienced for traffic on one minor street approach controlled by a STOP sign equals or exceedds four vehicle-hours for a one-lane approach and five vehicle-hours for a two-lane approach; AND Yes ☐ No ☐
2. The volume on the same minor street approach equals or exceeds 100 vph for one moving lane of traffic or 150 vph for two moving lanes; AND Yes ☐ No ☐
3. The total entering volume serviced during the hour equals or exceeds 800 vph for intersections with four or more approaches or 650 vph for intersections with three approaoches. Yes ☐ No ☐

PART B **SATISFIED YES ☐ NO ☐**

APPROACH LANES	One	2 or More				Hour
Both Approaches - Major Street						
Highest Approaches - Minor Street						

The plotted points for vehicles per hour on major streets (both approaches) and the corresponding per hour higher volume vehicle minor street approach (one direction only) for one hour (any consecutive 15 minute period) fall above the applicable curves in MUTCD Figure 4C-3 or 4C-4.

Figure 4C-101 (CA). Traffic Signal Warrants Worksheet (Sheet 3 of 4)

DIST _____ CO _____ RTE _____ KPM _____

CALC _____ DATE _____
CHK _____ DATE _____

Major St: _____ Critical Approach Speed _____ km/h
Minor St: _____ Critical Approach Speed _____ km/h

Critical speed of major street > 64 km/h (40 mph)..... ☐
or
In built up area of isolated community of < 10,000 population..... ☐
} **RURAL (R)**

☐ **URBAN (U)**

WARRANT 4 - Pedestrian Volume
(All Parts Must Be Satisfied)

100% SATISFIED YES ☐ NO ☐

Hours - - ->						
Pedestrian Volume					Any hour > 190	Yes ☐ No ☐
					OR 4 hours > 100	Yes ☐ No ☐
Adequate Crossing Gaps					AND < 60 gap/hr	Yes ☐ No ☐

AND, The distance to the nearest traffic signal along the major street is greater than 90m (300 ft) - - - - - - - - - - Yes ☐ No ☐

AND, The new traffic signal will not seriously disrupt progressive traffic flow in the major street. - - - - - - - - - - Yes ☐ No ☐

WARRANT 5 - School Crossing
(All Parts Must Be Satisfied)

SATISFIED YES ☐ NO ☐

Part A
Gap/Minutes and # of Children

Each of Two Hours - - - >					
Gaps vs Minutes	Minutes Children Using Crossing				
	Number of Adequate Gaps			Gaps < Minutes	SATISFIED YES ☐ NO ☐
School Age Pedestrians Crossing Street				Children > 20/hr	SATISFIED YES ☐ NO ☐

Part B
Distance to Nearest Controlled Crossing

Is Nearest Controlled Crossing More Than 180 m (600 ft) away? SATISFIED YES ☐ NO ☐

Figure 4C-101 (CA). Traffic Signal Warrants Worksheet (Sheet 4 of 4)

WARRANT 6 - Coordinated Signal System **SATISFIED YES ☐ NO ☐**
(All Parts Must Be Satisfied)

MINIMUM REQUIREMENTS	DISTANCE TO NEAREST SIGNAL	FULFILLED
> 300 m (1000 ft)	N _____ m, S _____ m, E _____ m, W _____ m	Yes ☐ No ☐
On one way isolated streets or streets with one way traffic significance and adjacent signals are so far apart that necessary platooning and speed control would be lost.		
On 2-way streets where adjacent signals do not provide necessary platooning and speed control proposed signals could constitute a progressive signal system.		☐ ☐

WARRANT 7 - Crash Experience Warrant **SATISFIED YES ☐ NO ☐**
(All Parts Must Be Satisfied)

REQUIREMENTS	WARRANT 1	✓	FULFILLED
One Warrant Satisfied 80%	Condition A - Minimum Vehicular Volume		
	OR		
	Condition B - Interruption of Continuous Traffic		Yes ☐ No ☐
Signal Will Not Seriously Disrupt Progressive Traffic Flow			☐ ☐
Adequate Trial of Less Restrictive Remedies Has Failed to Reduce Crash Frequency			☐ ☐
Crashes Within a 12 Mo. Period Susceptible for Corr. & Involving Injury or ≥ $500 Damage			
MINIMUM REQUIREMENTS	NUMBER OF CRASHES		
5 or More			☐ ☐

WARRANT 8 - Roadway Network **SATISFIED YES ☐ NO ☐**
(All Parts Must Be Satisfied)

MINIMUM VOLUME REQUIREMENTS	ENTERING VOLUMES - ALL APPROACHES		✓	FULFILLED
1000 Veh/Hr	During Typical Weekday Peak Hour _____ Veh/Hr			
	OR			
	During Each of Any 5 Hrs. of a Sat. and/or Sun _____ Veh/Hr			Yes ☐ No ☐
CHARACTERISTICS OF MAJOR ROUTES		MAJOR ROUTE A	MAJOR ROUTE B	
Hwy. System Serving as Principal Network for Through Traffic				
Rural or Suburban Highway Outside Of, Entering, or Traversing a City				
Appears as Major Route on an Official Plan				
Any Major Route Characteristics Met, Both Streets				☐ ☐

The satisfaction of a warrant is not necessarily justification for a signal. Delay, congestion, confusion or other evidence of the need for right-of-way assignment must be shown.

Figure 4C-102 (CA). Traffic Count Worksheet

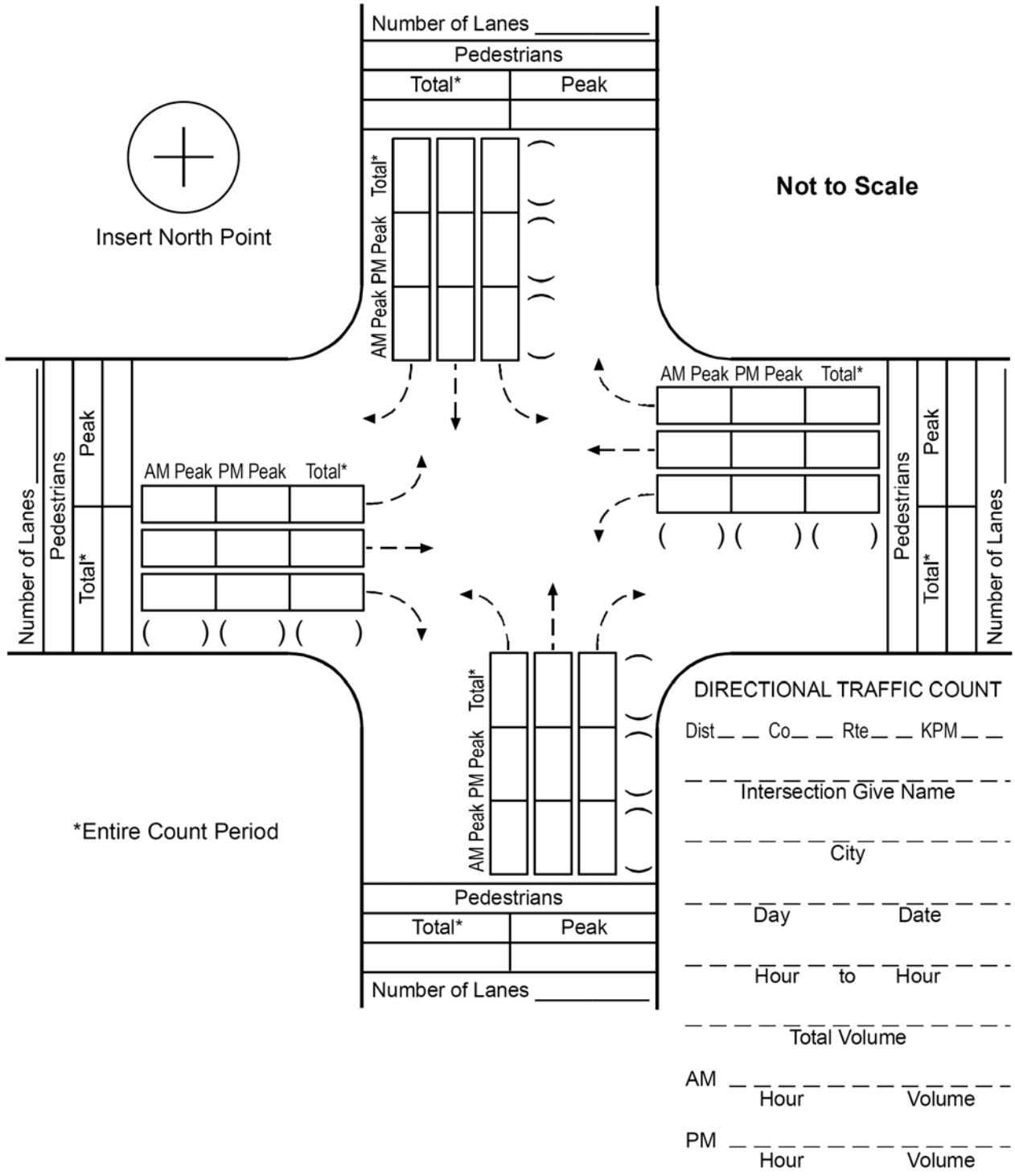


Table 4C-101 (CA). Traffic Signal Warrants Worksheet (Average Traffic Estimate Form)

(Based on Estimated Average Daily Traffic - See Note)

URBAN..... RURAL.....	Minimum Requirements EADT	
1A - Minimum Vehicular Traffic Satisfied _____ Not Satisfied _____	Vehicles Per Day on Major Street (Total of Both Approaches)	Vehicles Per Day on Higher-Volume Minor Street Approach (One Direction Only)
Number of lanes for moving traffic on each approach	Urban / Rural	Urban / Rural
Major Street / Minor Street		
1 / 1	8,000 / 5,600	2,400 / 1,680
2 or More / 1	9,600 / 6,720	2,400 / 1,680
2 or More / 2 or More	9,600 / 6,720	3,200 / 2,240
1 / 2 or More	8,000 / 5,600	3,200 / 2,240
1B - Interruption of Continuos Traffic Satisfied _____ Not Satisfied _____	Vehicles Per Day on Major Street (Total of Both Approaches)	Vehicles Per Day on Higher-Volume Minor Street Approach (One Direction Only)
Number of lanes for moving traffic on each approach	Urban / Rural	Urban / Rural
Major Street / Minor Street		
1 / 1	12,000 / 8,400	1,200 / 850
2 or More / 1	14,400 / 10,080	1,200 / 850
2 or More / 2 or More	14,400 / 10,080	1,600 / 1,120
1 / 2 or More	12,000 / 8,400	1,600 / 1,120
1A&B - Combinations Satisfied _____ Not Satisfied _____ No one warrant satisfied, but following warrants fulfilled 80% or more..... _____ (1) _____ (2)	2 Warrants	2 Warrants

Note: To be used only for NEW INTERSECTIONS or other locations where it is not reasonable to count actual traffic volumes.